

organic electrolyte. Consequently, it was considered that the self-discharge of the battery and the unevenness of the separator were prevented.

The result of the battery of Comparative Example 2 was not shown in Table 1 since it became unable to repeat charge/discharge cycle on halfway. This was presumably because sol-gel transition of the gel electrolyte and oxidation decomposition reaction of an ethylene oxide unit occurred at high temperatures since it used polyethylene oxide only as the host polymer.

As to the size of the side-chain comprising an acrylate unit or methacrylate unit and an alkylene oxide unit, the effect of improving the storage characteristic at high temperatures was explicit when the average molecular weight was 300 to 1,600, as was clear from Examples 4, 5, 11 and 12. It was considered that when the side-chain was too short, the function of retaining the liquid organic electrolyte was insufficient; when the side-chain was too long, the property of the ethylene oxide unit appeared strongly and was readily decomposed at high temperatures. Similarly, when the content of the side-chain was too small, the property of the polyvinylidene fluoride appeared strongly; when it was too large, the property of the polyethylene oxide appeared strongly.

Table 2 shows that the battery of Example 7 wherein a modified copolymer of vinylidene fluoride-hexafluoropropylene

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is used as the binder for the positive electrode and a particulate rubber containing a styrene unit, a butadiene unit and an acrylate unit is used as the binder for the negative electrode, has the highest capacity maintenance rate. On the other hand, the battery of Example 10, wherein an unmodified polyvinylidene fluoride is used as the binder for the positive electrode and an unmodified copolymer of vinylidene fluoride-hexafluoropropylene is used as the binder for the negative electrode, has a relatively small effect of improvement in the capacity maintenance rate at high temperatures.

The reason why there was such a difference in the effect of improvement in the capacity maintenance rate at high temperatures was presumably due to the difference in the bonding property between the electrode plate and the separator and the degree of deformity of the electrode plate.

The batteries of Examples 8 and 9 used as the binder for the negative electrode a modified polyvinylidene fluoride having an oxygen-containing group or an ionomer containing an acrylate unit, which did not readily swell in the liquid organic electrolyte and which had a high ability of bonding between the current collector and the negative electrode mixture, and binding between the active material particles. Consequently, these batteries had a further improved stability at high temperatures as compared with the battery of Example 10 using a copolymer of vinylidene fluoride-hexafluoropropylene which readily swelled in the liquid

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That is, when a copolymer of vinylidene fluoride-hexafluoropropylene is used as the binder for the negative electrode, the binder and the liquid organic electrolyte form a gel during charging at high temperatures, and along with that, the negative electrode swells to cut the electronically conductive network in the negative electrode, thereby reducing the capacity of the battery. On the other hand, when a modified polyvinylidene fluoride having an oxygen-containing group or an ionomer containing at least one of an acrylate unit and methacrylate unit, which does not readily swell in the liquid organic electrolyte, which has a high ability as the binder and which has a good bonding property with the separator, is used as the binder of the negative electrode, the deformation of the negative electrode by swelling or expansion is suppressed to minimum and thus the storage characteristics at high temperatures of the battery can be improved effectively.

The present invention uses a crosslinked copolymer having a main-chain comprising a vinylidene fluoride unit and a side-chain comprising an alkylene oxide unit and at least one of an acrylate unit and methacrylate unit as the host polymer of the gel electrolyte, and the invention preferably uses a binder which does not readily swells in the liquid organic electrolyte as the binder of the positive electrode and the negative electrode, so that a highly reliable polymer